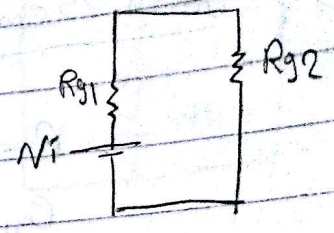
Sheet 2



(1) $R_{g1} = \frac{g}{\mu_0 A} = \frac{g}{\mu_0 \pi 2.5^2 \times 10^{-4}}$

$R_{g1} = \frac{509.296}{\mu_0} g \quad AT/wb$

$R_{g2} = \frac{L}{\mu_0 A} = \frac{0.02 \times 10^{-2}}{\mu_0 (2\pi\ 0.05 * 0.015)} = 33773.73 \quad AT/wb$

$R_T = 33773.73 + \frac{509.296}{\mu_0} g$

for $g = 0.25$ cm

$A_{g1} = \pi 2.5^2 \times 10^{-4} = 1.963 \times 10^{-3} \ m^2$

$R_T = 1046985.9 \quad AT/wb$

$B_{g1} = \frac{\Phi}{A_{g1}} = \frac{Ni}{R_T A_{g1}} = \frac{3000}{1046985.9 * 1.963 \times 10^{-3}}$

$B_{g1} = 1.459 \ T$

$L = \frac{N^2}{R_T} = \frac{1000^2}{1046985.9} = 0.955 \ H$

$W = \frac{1}{2} L I^2 = 4.298 \ J$

for $g = 0.5$ cm

$R_T = 2060198 \quad AT/wb$

$B_{g1} = 0.7418 \ T$

$L = 0.488 \ H$

$W = 2.184 \ J$

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for g = 1.25 cm

$R_T = 5099834$ AT/Wb

$B_{g1} = 0.3$ T

$L = 0.196$ H

$W = 0.882$ J

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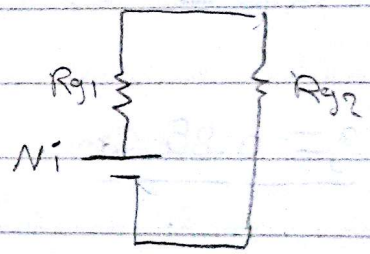
(2) R_{g1} = upper airgap R_{g2} = lower



$$R_{g1} = \frac{t}{\mu_0 \pi d x}$$

$$R_{g2} = \frac{t}{\mu_0 \pi d a}$$

$$R_T = \frac{t}{\mu_0 \pi d}\left(\frac{1}{x}+\frac{1}{a}\right) = \frac{t(x+a)}{\mu_0 \pi d x a}$$

$$L = \frac{N^2}{R_T} = \frac{\mu_0 N^2 \pi d x a}{t(x+a)}$$

$$W = \frac{1}{2} L I^2 = \frac{\mu_0 N^2 I^2 \pi d x a}{2t(x+a)}$$

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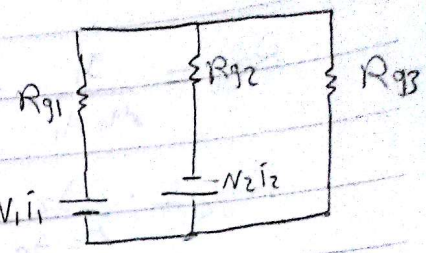
(3) R_{g1} = left R_{g2} = right R_{g3} = middle



$$R_{g1} = \frac{+}{\mu_0 \pi \delta (a-x)}$$

$$R_{g2} = \frac{+}{\mu_0 \pi \delta (a+x)}$$

$$R_{g3} = \frac{+}{\mu_0 \pi \delta w}$$

$$L_{11} = \frac{N_1^2}{R_{11}}$$

$$R_{11} = R_{g1} + R_{g2} // R_{g3} = \frac{+}{\mu_0 \pi \delta} \left[\frac{1}{a-x} + \frac{1}{a+x+w} \right]$$

$$\boxed{L_{11} = \frac{N_1^2 \mu_0 \pi \delta}{+\left[\frac{1}{a-x} + \frac{1}{a+x+w} \right]}}$$

$$L_{22} = \frac{N_2^2}{R_{22}}$$

$$R_{22} = R_{g2} + R_{g1} // R_{g3} = \frac{+}{\mu_0 \pi \delta} \left[\frac{1}{a+x} + \frac{1}{a-x+w} \right]$$

$$\boxed{L_{22} = \frac{N^2 \mu_0 \pi \delta}{+\left[\frac{1}{a+x} + \frac{1}{a-x+w} \right]}}$$

all the energy is stored in the air gap

$$W_g = \frac{B_g^2}{2\mu_0} V_g$$

$$\phi_1 = \frac{N_1 i_1}{R_{11}} + \frac{N_2 i_2}{R_{22}} \frac{R_{g3}}{R_{g1} + R_{g3}} \qquad (A_{g1} = \pi \delta (a-x))$$

$$\phi_2 = \frac{N_1 i_1}{R_{11}} \frac{R_{g3}}{R_{g2} + R_{g3}} + \frac{N_2 i_2}{R_{22}} \qquad (A_{g2} = \pi \delta a+x)$$

$$\phi_3 = \frac{N_1 i_1}{R_{11}} \frac{R_{g2}}{R_{g2} + R_{g3}} - \frac{N_2 i_2}{R_{22}} \frac{R_{g1}}{R_{g1} + R_{g3}}$$

$(A_{g3} = \pi \delta w)$

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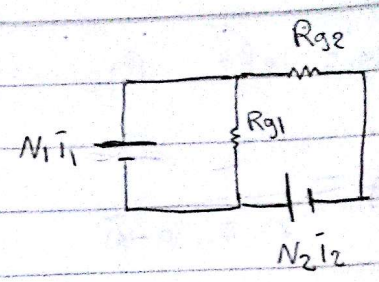
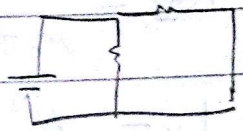
$$R_{g1} = \frac{g_1}{\mu_0 A_1} = 3183098 \text{ AT/wb}$$

$$R_{g2} = \frac{g_2}{\mu_0 A_2} = 3183098 \text{ AT/wb}$$

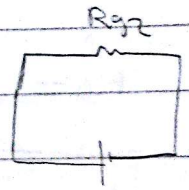


$$R_{11} = R_{g1} // R_{g2} = 1591549 \text{ AT/wb}$$

a- $$\boxed{L_{11} = \frac{N_1^2}{R_{11}} = 0.157 \text{ H}}$$

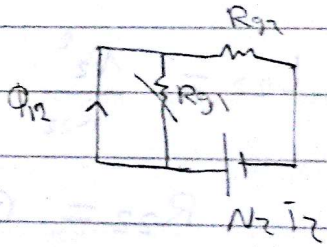


$$R_{22} = R_{g2} = 3183098 \text{ AT/wb}$$



b- $$\boxed{L_{22} = 78.54 \text{ mH}}$$

c- $$M = \frac{\lambda_{12}}{I_2} = \frac{N_1 \phi_{12}}{I_2}$$

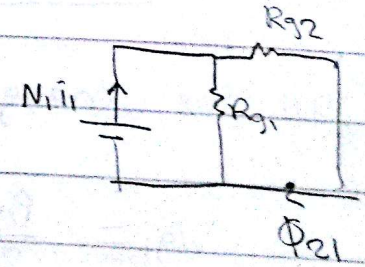


$$\phi_{12} = \frac{N_2 I_2}{R_{g2}}$$

$$\boxed{M = \frac{N_1 N_2}{R_{g2}} = 78.54 \text{ mH}}$$

OR

$$M = \frac{\lambda_{21}}{I_1} = \frac{N_2 \phi_{21}}{I_1}$$



$$\phi_{21} = \frac{N_1 I_1}{R_{11}} \cdot \frac{R_{g1}}{R_{g1} + R_{g2}}$$

$$\phi_{21} = \frac{N_1 I_1}{R_{g2}}$$

$$M = \frac{N_1 N_2}{R_{g2}}$$

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$$W = \frac{1}{2} L_1 I_1^2 + \frac{1}{2} L_2 I_2^2 \pm M I_1 I_2$$

1- $I_2 = 0$

$$W = \frac{1}{2} L_1 I_1^2$$

2- $I_1 = 0$ $\quad W = \frac{1}{2} L_2 I_2^2$

3- $W = \frac{1}{2} L_1 I_1^2 + \frac{1}{2} L_2 I_2^2 + M I_1 I_2$

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